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Jacobs et al.

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(54) **INK BARRIER FORMED ON PRINTHEAD TO PREVENT AIR INTAKE**

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(22) Filed: **Apr. 7, 2015**

(51) **Int. Cl.**

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B41J 2/16	(2006.01)
B41J 2/165	(2006.01)
B41J 2/14	(2006.01)

(52) **U.S. Cl.**
CPC ***B41J 2/16538*** (2013.01); ***B41J 2/1433*** (2013.01)

(58) **Field of Classification Search**
CPC .. B41J 2/1652; B41J 2/16535; B41J 2/16552; B41J 2/16538; B41J 2/16505; B41J 2/16547; B41J 2/1707; B41J 2/1714; B41J 2/16544; B41J 2/1721
See application file for complete search history.

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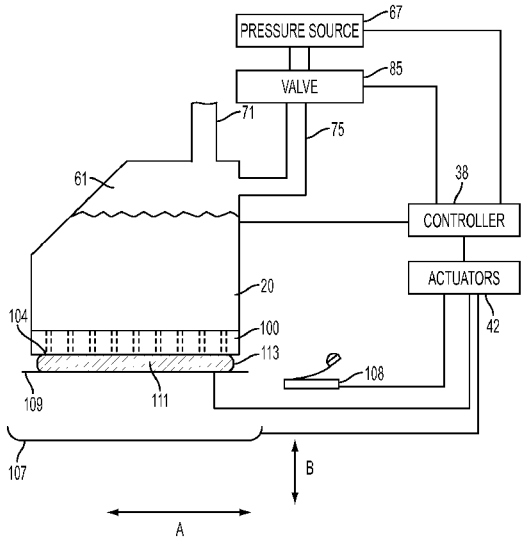
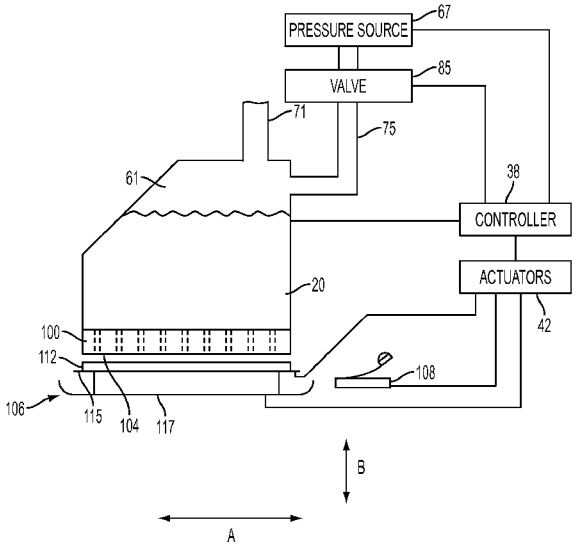
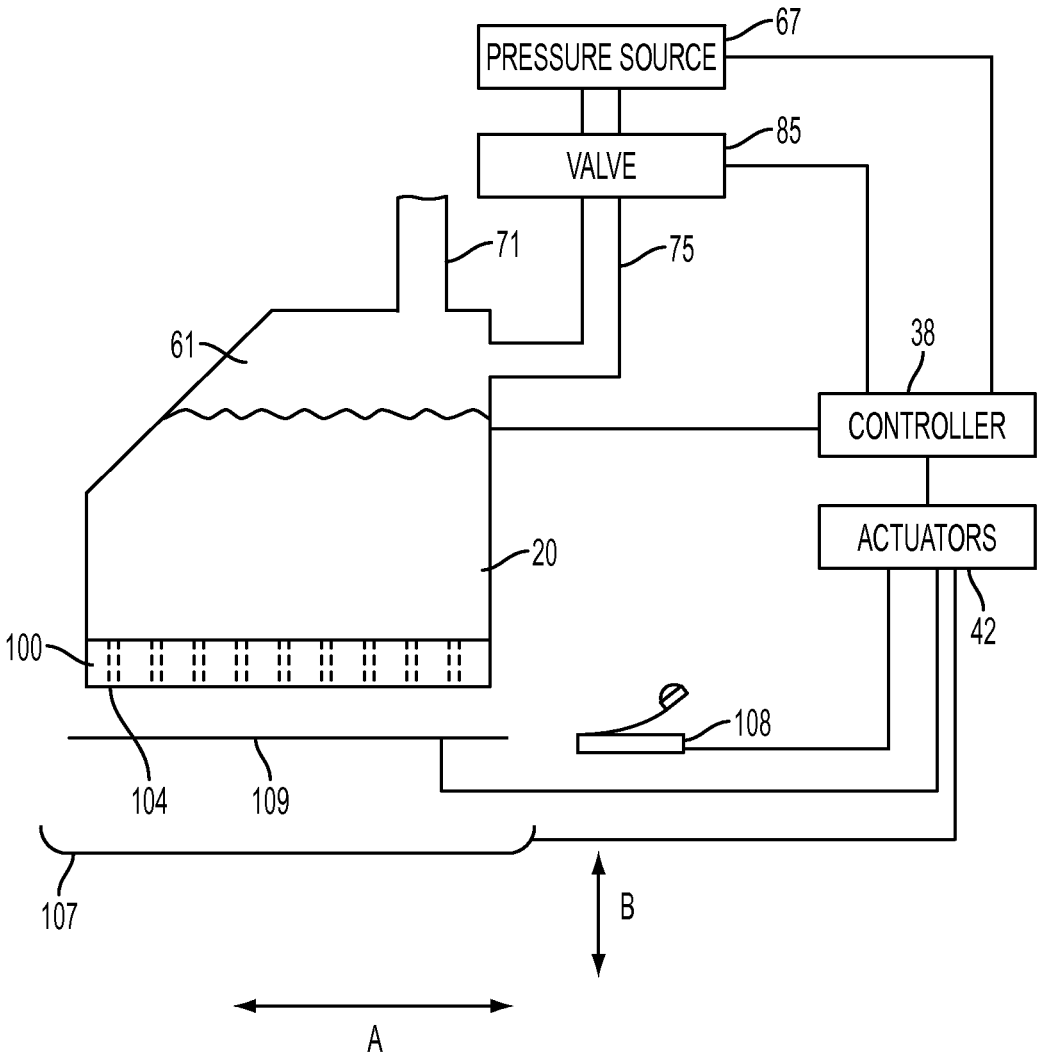
(57) **ABSTRACT**

An imaging device includes at least one printhead including an aperture plate defining a plurality of apertures, an ink plate and a controller. The at least one printhead is configured to eject liquid ink through the plurality of apertures of the aperture plate. The ink plate is positioned with reference to the aperture plate to enable an ink layer to form between the ink plate and the aperture plate by ink ejected by the printhead. The controller operatively connected to the printhead and configured to operate the printhead to eject the liquid ink to the ink plate to form the link layer.

17 Claims, 6 Drawing Sheets






PRESSURE SOURCE
67
VALVE
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CONTROLLER
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B
A

FIG. 1

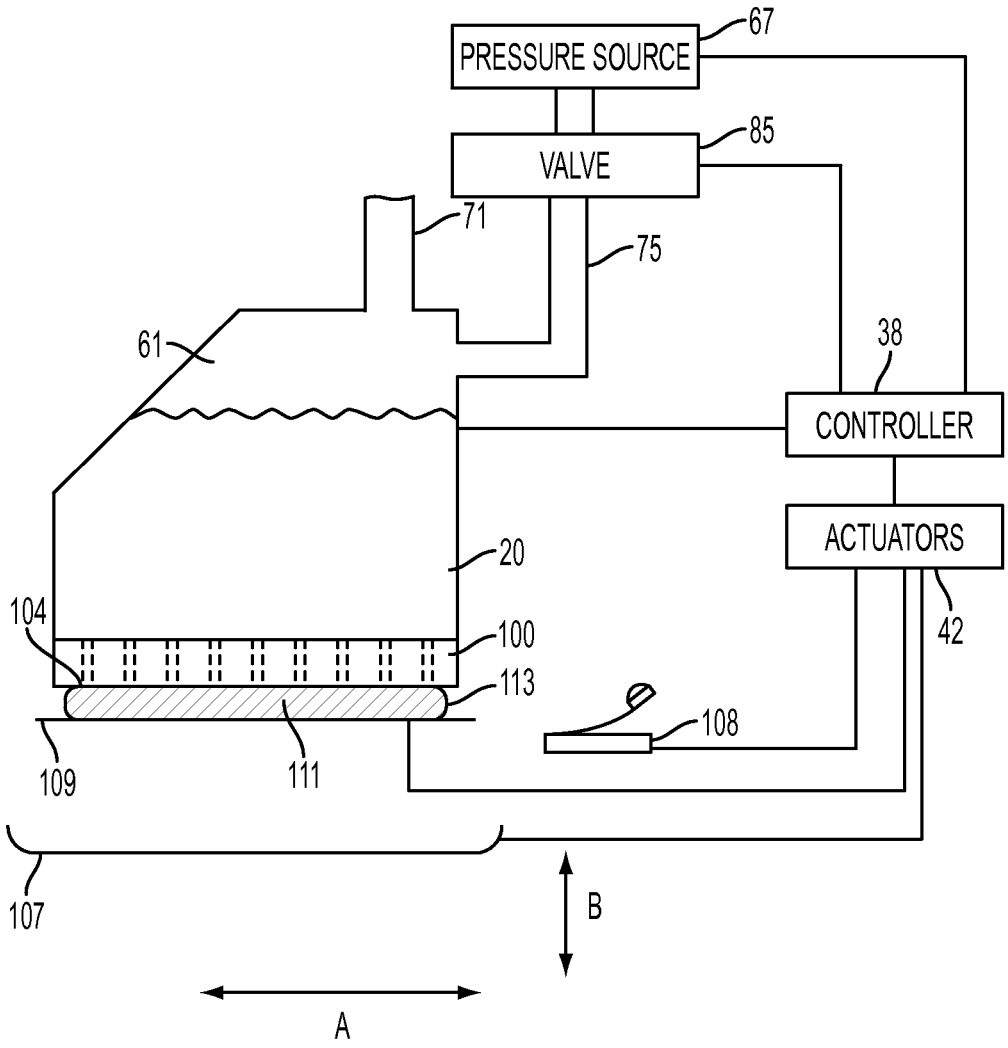
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FIG. 2

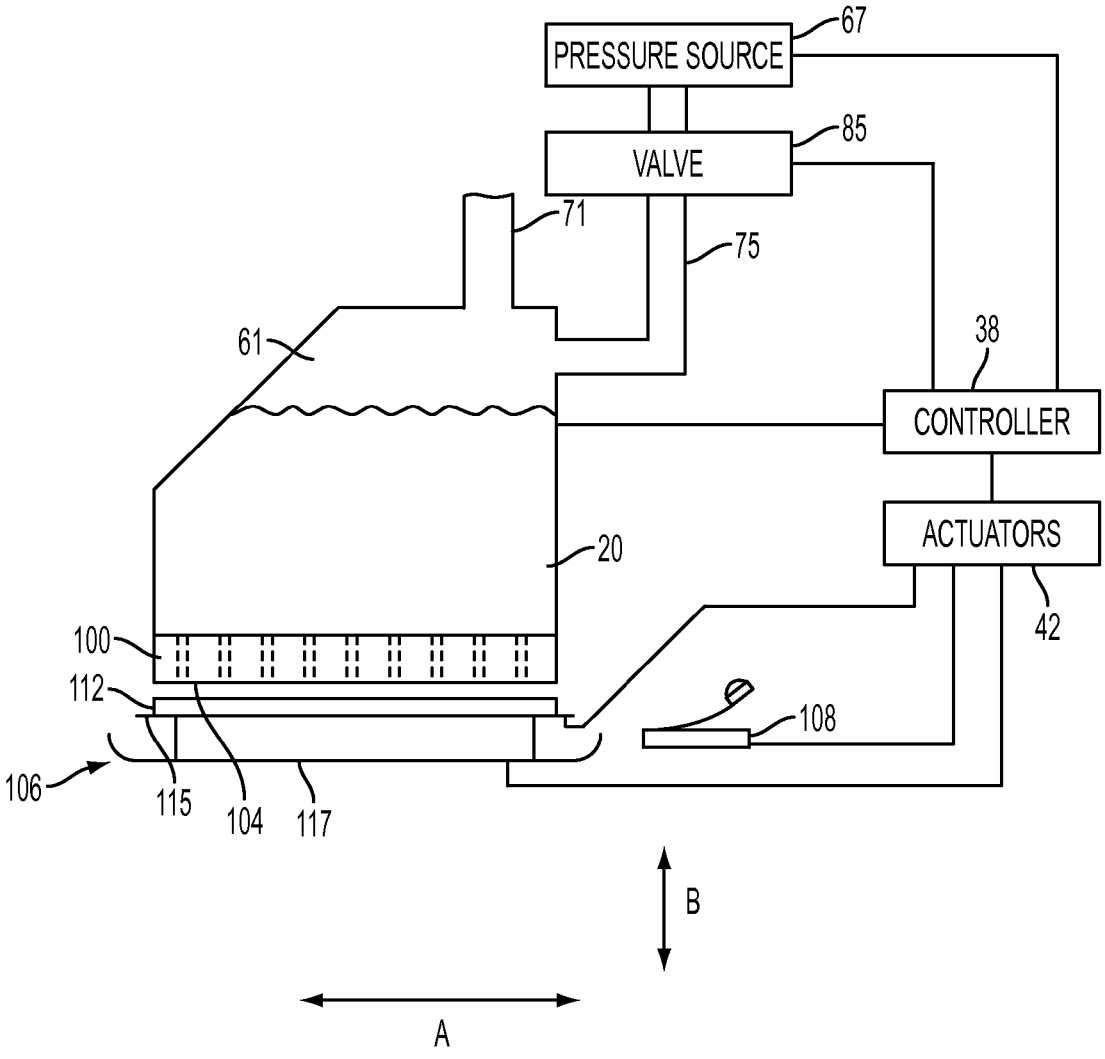
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FIG. 3

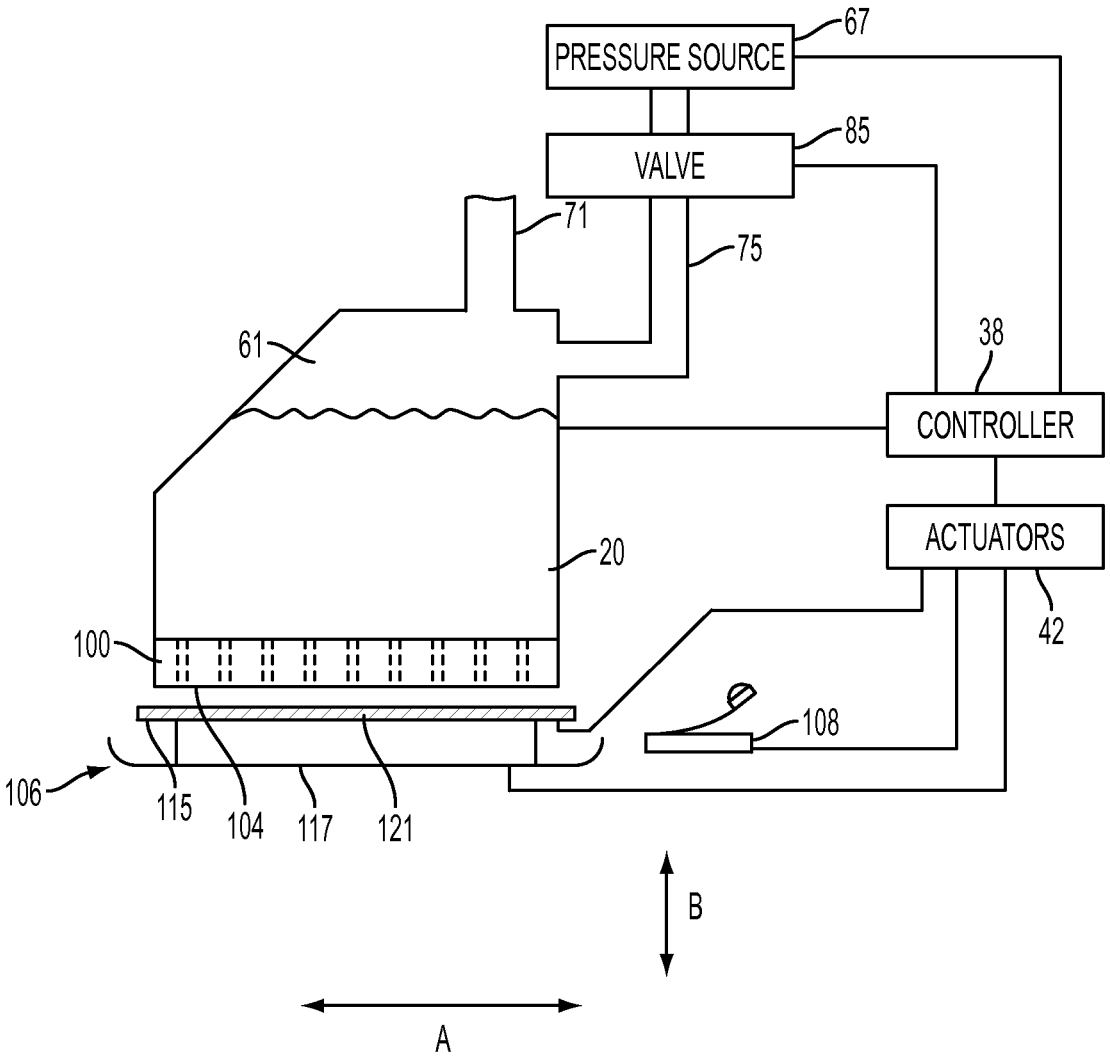
PRESSURE SOURCE
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FIG. 4

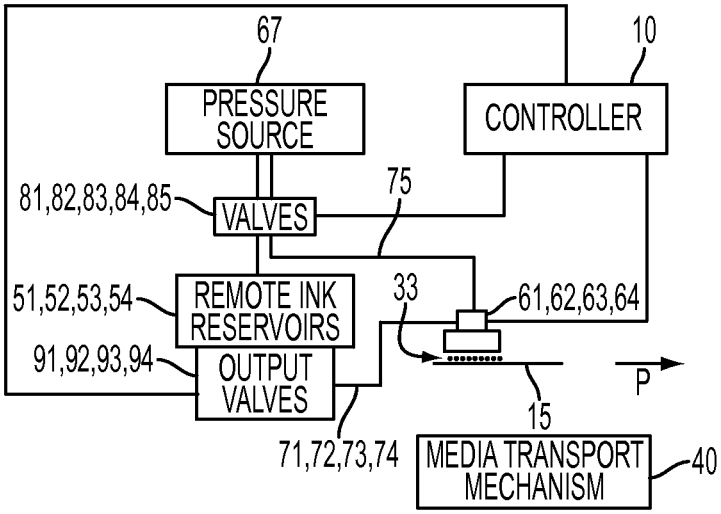

FIG. 5
PRIOR ART

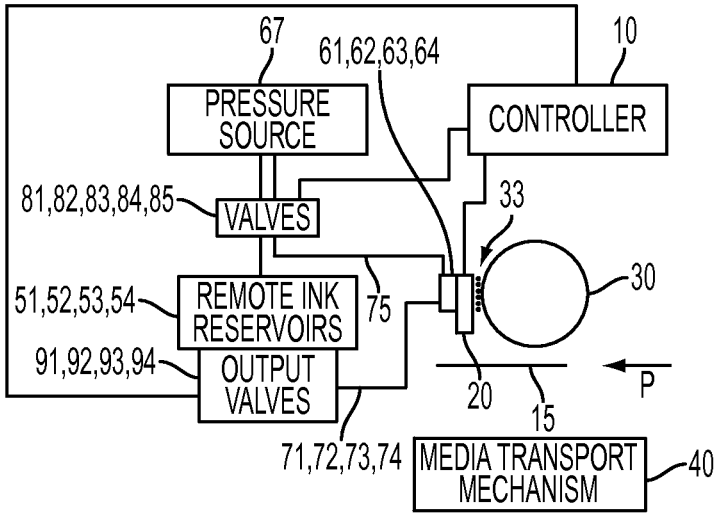

FIG. 6
PRIOR ART

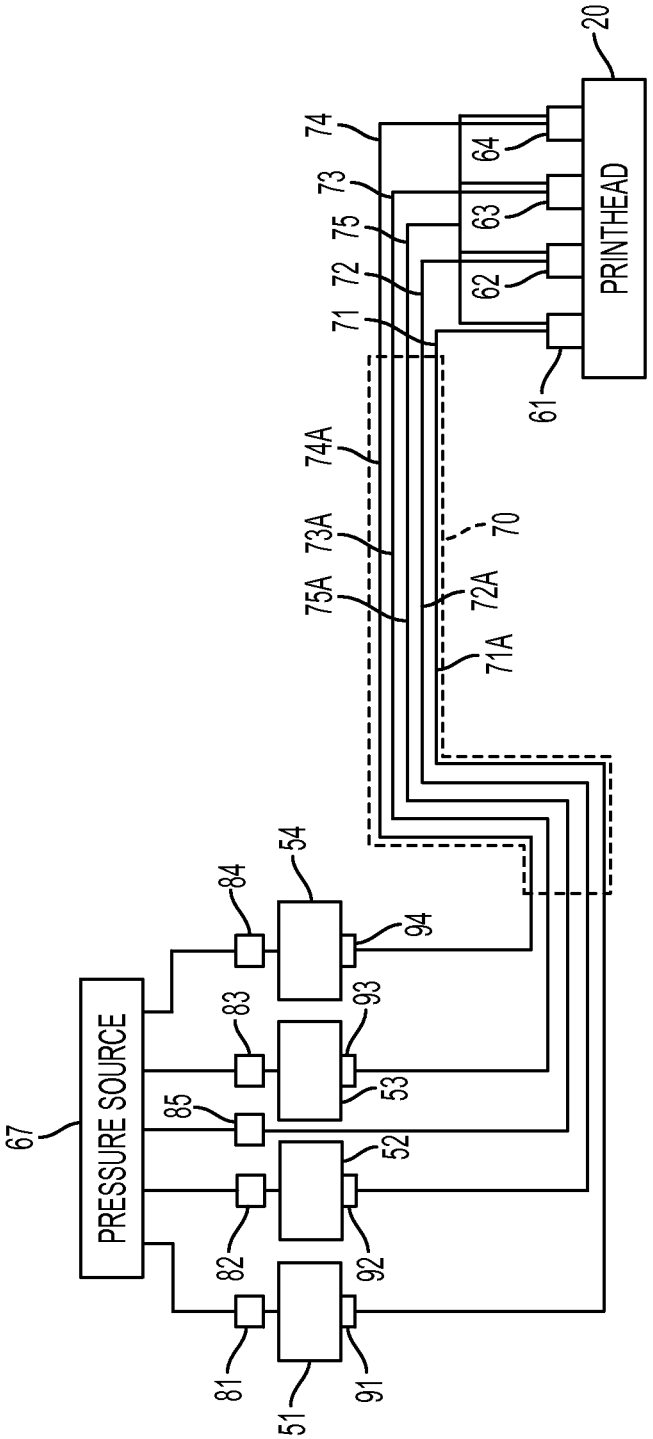

FIG. 7
PRIOR ART

INK BARRIER FORMED ON PRINTHEAD TO PREVENT AIR INTAKE

TECHNICAL FIELD

This disclosure relates generally to printheads of an inkjet imaging device, and, in particular, to methods for preventing air and other debris from entering such printheads.

BACKGROUND

A typical inkjet printer typically uses a printhead assembly that includes one or more printheads. Each printhead has a plurality of inkjets from which drops of ink are ejected towards a recording medium. The inkjets of a printhead receive the ink from an ink manifold in the printhead that is supplied ink from a source, such as an ink reservoir or an ink cartridge. Each inkjet also includes an actuator positioned opposite an orifice, or nozzle, through which drops of ink are ejected. The nozzles of the inkjets may be formed in an aperture, or nozzle, plate that has openings corresponding to the nozzles of the inkjets. During operation, drop ejecting signals activate the actuators in the inkjets to expel drops of fluid through the inkjet nozzles onto the recording medium. By selectively activating the actuators of the inkjets to eject drops as the recording medium and printhead assembly move relative to each other, the deposited drops can be precisely patterned to form particular text and graphic images on the recording medium.

One difficulty faced by inkjet systems is the risk of sucking air or other contaminants, such as dust and paper fibers, into the printhead through the inkjet nozzles. These contaminants disrupt the fluidic path for the ink through the printhead. Such disruption from the air or contaminants can result in missing, undersized or misdirected drops on the recording media that degrade the print quality during printer operation, and even render one or more inkjets in the printhead completely inoperable. Air and other contaminants may enter the printhead nozzles in many situations. For example, negative pressures may develop within the printhead resulting in air being drawn in through the nozzles when the printhead is subjected to a sudden external impact or jolt, or when a hose is disconnected upstream of the printhead. In another example, negative pressure develops due to changing pressures in the external environment, such as when the printer is shipped in a shipping container. Consequently, printer improvements that help prevent air and other contaminants from entering a printhead are desirable.

SUMMARY

An imaging device that helps prevent air and other contaminants from entering a printhead includes a printhead including an aperture plate defining a plurality of apertures, the printhead configured to emit liquid ink through the plurality of apertures of the aperture plate, a plate positioned with reference to the aperture plate to enable a liquid ink layer to form between the plate and the aperture plate with ink emitted from the printhead, and a controller operatively connected to the printhead and configured to operate the printhead to emit the liquid ink to the plate to form the ink layer.

A method of operating an imaging device helps prevent air and other contaminants from entering a printhead in the device. The method includes positioning at least one of a printhead and a plate with reference to each other at a distance to enable an ink layer to be formed between an aperture plate of the printhead and the plate with liquid ink emitted by the printhead, and operating with a controller the printhead to emit liquid ink through a plurality of apertures defined in the aperture plate of the printhead to the plate to form the ink layer between the plate and the aperture plate.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and other features of the present disclosure are explained in the following description, taken in connection with the accompanying drawings.

FIG. **1** is a simplified side cross-sectional view of an embodiment of a printhead positioned by a plate, receptacle and wiper blade.

FIG. **2** is a simplified side cross-sectional view of an embodiment of the printhead positioned by a plate, receptacle and wiper blade of FIG. **1** depicting an ink layer with a meniscus formed between the aperture plate of the printhead and the plate.

FIG. **3** is a simplified side cross-sectional view of an embodiment of a printhead positioned by a plate and receptacle assembly, and a wiper blade.

FIG. **4** is an illustration of a plate having an absorbent layer that is used to form an ink layer between a printhead and the plate.

FIG. **5** is a schematic block diagram of an embodiment of a prior art inkjet printing apparatus that includes on-board ink reservoirs.

FIG. **6** is a schematic block diagram of another embodiment of a prior art inkjet printing apparatus that includes on-board ink reservoirs.

FIG. **7** is a schematic block diagram of an embodiment of prior art ink delivery components of the inkjet printing apparatus of FIGS. **5** and **6**.

DETAILED DESCRIPTION

For a general understanding of the present embodiments, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate like elements.

As used herein, the term "imaging device" generally refers to a device for applying an image to print media. "Print media" may be a physical sheet of paper, plastic, or other suitable physical print media substrate for images, whether precut or web fed. The imaging device may include a variety of other components, such as finishers, paper feeders, and the like, and may be embodied as a copier, printer, or a multifunction machine. A "print job" or "document" is normally a set of related sheets, usually one or more collated copy sets copied from a set of original print job sheets or electronic document page images, from a particular user, or otherwise related. An image generally may include information in electronic form which is to be rendered on the print media by a marking engine and may include text, graphics, pictures, and the like. As used herein, the process direction is the direction in which an image receiving surface, e.g., media sheet, web, or intermediate transfer drum or belt, moves through the imaging device. The cross-process direction, along the same plane as the image receiving surface, is substantially perpendicular to the process direction.

FIGS. **5** and **6** are schematic block diagrams of embodiments of a previously known inkjet printing apparatus that includes a controller **10** and a printhead **20** that includes a plurality of inkjets for ejecting drops of ink **33** either directly onto a print output medium **15** (FIG. **5**) or onto an intermediate transfer surface **30** before being transferred to media **15** (FIG. **6**). The controller **10** operates the inkjets with reference

to image data to form images on media **15** or surface **30** as the media or surface passes by the printhead **20**. A medium transport mechanism **40** moves the medium in a process direction P. The printhead **20** receives ink from a plurality of on-board ink reservoirs **61**, **62**, **63**, **64**, which are attached to the printhead **20**. The on-board ink reservoirs **61-64** respectively receive ink from a plurality of remote ink containers **51**, **52**, **53**, **54** via respective ink supply channels **71**, **72**, **73**, **74**. Alternatively, the ink can come directly from the remote containers **51**, **52**, **53**, **54** to the printhead **20** and reservoirs **61-64** are not incorporated in the printhead.

Although not depicted in FIG. **5** or **6**, inkjet printing apparatus includes an ink delivery system for supplying ink to the remote ink containers **51-54**. In one embodiment, the ink is an aqueous ink which is in liquid form at room temperature. However, in alternative embodiments, any suitable marking material or ink may be used, including, for example, phase-change ink, gel ink, oil-based ink, UV curable ink, or the like and may or may not need to be melted to achieve the correct properties for ejecting the ink.

The remote ink containers **51-54** are configured to deliver ink to the on-board ink reservoirs **61-64**. In one embodiment, the remote ink containers **51-54** may be selectively pressurized, for example by compressed air that is provided by a pressure source **67** via a plurality of valves **81**, **82**, **83**, **84**. These values are operatively connected to the controller **10** to enable the controller to operate the valves as described below. The flow of ink from the remote containers **51-54** to the on-board reservoirs **61-64** may be under pressure or by gravity, for example. Output valves **91**, **92**, **93**, **94** may be provided to control the flow of ink to the on-board ink reservoirs **61-64**. These valves are also operatively connected to the controller **10** to enable operation of the valves by the controller. The pressure source may be configured to deliver air under pressure to the on-board reservoir at a plurality of different pressure levels. The plurality of pressure levels may be provided by using a variable speed air pump or by controlling valve **85** to bleed off pressure from the pressure supplied by the air pump until a desired pressure level is reached. As explained below, the plurality of pressure levels include at least a purge pressure and an assist pressure.

The on-board ink reservoirs **61-64** may also be selectively pressurized, for example, by selectively pressurizing the remote ink containers **51-54** and pressurizing an air channel **75** via a valve **85**. Alternatively, the ink supply channels **71-74** may be closed, for example, by closing the output valves **91-94**, and the air channel **75** may be pressurized. The on-board ink reservoirs **61-64** may be pressurized to perform a cleaning or purging operation on the printhead **20**, for example. The on-board ink reservoirs **61-64** are vented to atmosphere during normal printing operation, for example, by controlling the valve **85** to vent the air channel **75** to atmosphere. The on-board ink reservoirs **61-64** may also be vented to atmosphere during non-pressurizing transfer of ink from the remote ink containers **51-54** (i.e., when ink is transferred without pressurizing the on-board ink reservoirs **61-64**).

As schematically depicted in FIG. **7**, a portion of the ink supply channels **71-74** and the air channel **75** may be implemented as conduits **71**A, **72**A, **73**A, **74**A, **75**A in a multi-conduit cable **70**. Once pressurized ink reaches a printhead via an ink supply channel, it is collected in an on-board reservoir. The on-board reservoir is configured to communicate ink to an inkjet stack **100** that includes a plurality of inkjets (not shown) for ejecting the ink onto a print medium (FIG. **10**) or an intermediate transfer member such as transfer drum **30** (FIG. **11**).

One difficulty that occurs in fluid inkjet systems is inkjet contamination due to the introduction of air and other contaminants into the printhead that can cause poor print quality and even render the printhead inoperable. With reference to FIG. **1**, a printhead and other components of an image forming device are shown that are configured to perform an air and debris prevention procedure to prevent air and other contaminants from entering the printhead, and further configured to perform a purge and wipe procedure to clean contaminated jets. The embodiment shown in FIG. **1** includes a printhead **20**, such as the printhead **20** of FIGS. **10-12**, can have at least one on-board reservoir **61**, although it is not necessary, and an inkjet stack **100**. The inkjet stack **100** can be formed in many ways, but in this example, it is formed of multiple laminated sheets or plates, such as stainless steel plates. Cavities etched into each plate align to form channels and passageways that define the inkjets and manifolds for the printhead. An outer plate comprises the aperture plate **104** that includes a plurality of apertures, which are shown in phantom in the aperture plate **104**, corresponding to each inkjet through which drops of ink are ejected.

The embodiment of FIG. **1** further includes a receptacle **107**, a scraper or wiper blade **108**, an ink plate **109**, and a controller **38**. The controller **38** is operatively connected to the printhead **20** and the actuators **42**, which are operatively connected to the receptacle **107**, and the wiper **108**, and the ink plate **109** to enable the controller **38** to operate the printhead and to move the ink plate, the receptacle, and the wiper. The actuators are configured to move components operatively connected to the actuators bi-directionally along axis B and axis A, which is substantially parallel to the front surface of the aperture plate.

To prevent air and other contaminants from entering the printhead, the embodiment of FIG. **1** is configured to help prevent printhead contamination from air and other debris by forming an ink layer between the aperture plate **104** of the printhead **20** and the ink plate **109**. The ink layer overlies the nozzles of the inkjets and acts as a barrier to air and other contaminants. If a negative pressure occurs within the printhead, the ink from the ink layer, and not air or other contaminants, is drawn into the printhead.

In most embodiments having the plate **109**, the receptacle **107** is moved opposite the printhead to catch ink wiped from the aperture plate during a purge ink maintenance operation, which is performed in a known manner to clear inoperative inkjets and remove debris and other contaminants from the aperture plate **104**. If the printhead is going to remain out of service, such as when a maintenance procedure is performed during extended down time for the printer, the controller **38** operates the actuators **42** to move the ink plate **109** between the aperture plate **104** and the receptacle **107** to a position aligned with and spaced from the aperture plate **104** as shown in FIG. **1**. At this position, the plate **109** covers the apertures of the aperture plate **104** at a predetermined distance from the aperture plate **104**. After the ink plate **109** is so positioned with respect to the aperture plate **104**, with reference to FIG. **2**, the controller **38** operates a pressure source **67**, such as those noted above, to produce positive pressure within the printhead **20** to urge ink through the apertures on the plate **104** and form an ink barrier or layer **111** between the ink plate **109** and the aperture plate **104**. Alternatively, the ink may be ejected from the printhead **20** by operating the actuators in inkjets. The distance between the aperture plate **104** and the ink plate **109**, and the amount of ink emitted from the printhead **20** is selected to ensure that the ink layer **111** forms a meniscus **113** along the perimeter of the ink layer between the aperture plate **104** and the ink plate **109**. Thus, the presence of

the plate **109** and the barrier **111** helps preserve the clean state of the aperture plate and the integrity of the inkjets following the purging procedure.

The meniscus **113** forms due to the surface tension of the ink layer **111** based on the amount of ink emitted, and the close proximity of the aperture plate **104** to the ink plate **109**. The ink plate **109** can be as close as about 200 microns to the aperture plate **104** and as far as about six thousand microns to form the meniscus. Meniscus pressure ensures that the ink emitted from the printhead **20** that forms the ink layer **111** does not leak from the ink layer **111**. The ink layer **111** encloses the apertures of the aperture plate **104** and prevents air and other debris from entering the apertures of the printhead. Even if a negative pressure is generated within the printhead, for example, during a printhead disconnect process, ink is drawn from the ink layer **111** into the printhead, rather than air and other debris. The ink helps attenuate the presence of foreign particles that can enter the apertures and contaminate the inkjets.

In the embodiment of the inkjet printing apparatus shown in FIGS. **1-2**, the ink plate **109** is independent of the receptacle **107**. In another embodiment, as depicted in FIG. **3**, an ink plate **115** and a receptacle **117** are embodied together to form a maintenance assembly **106**. In the maintenance assembly **106**, the plate **115** is integrated with the receptacle **117** so it slides with reference to the receptacle. The controller **38** controls the actuators **42** to move the receptacle **117** of the maintenance assembly **106** opposite the printhead **20** to enable the receptacle **117** to receive ink from the face of the printhead **20** during the purging and wiping procedure. After the procedure is performed, the controller operates another actuator **42** to slide the ink plate **115** between the aperture plate **104** and the receptacle **107**. The inkjets in the printhead can then be operated to form the ink barrier **111** with ink emitted from the printhead. In some embodiments of plate **115**, a seal **112** is provided, as shown in FIG. **3**. The seal **112** forms a perimeter on the plate **115** and the plate **115** is moved to press the seal **112** against the aperture plate **104**. Thus, the seal **112** encloses the space in which ink is emitted to form the ink barrier **111**, which helps prevent the printhead from being contaminated. When the printhead is to be returned to service for printing, actuator **42** is operated to withdraw the plate **115** and enable the ink barrier **111** to drop into the receptacle **117**. Other actuators **42** can then be operated to move the receptacle **117** away from the printhead.

In some embodiments, the plate **109** and **115** is a metal plate. In other embodiments, such as the one shown in FIG. **4**, the ink plate has a foam layer **121**, or other absorbent material or coating, to help hold the ink against the aperture plate **104**. The absorbent layer is large enough to cover the footprint of the apertures on the aperture plate, but not so large as to exceed the perimeter of the receptacle beneath the plate. Also, the embodiments above are described with reference to a printhead that ejects liquid ink, such as an aqueous ink. The ink barrier plate could be used in printers that use phase change inks provided that either the plate or the printhead or both are heated to maintain the ink in the liquid phase. Otherwise, the ink would solidify between the plate and the printhead and leave a layer of solid ink on the printhead face, which is not desirable.

While positioning the receptacle **107** or **117** or the ink plate **109** or **115** has been described with reference to controlling actuators to move the components with respect to stationary printheads, other embodiments are contemplated. In one embodiment, both the printhead and the components are controlled to be moved with respect to each other in order to position the components with respect to the printhead. In yet another embodiment, only the printhead is controlled to be moved into position with respect to the components, while the components remain stationary except the plate and the receptacle move relative to one another to enable the purging and wiping procedure with the receptacle alone and the ink barrier formation to occur with both structures being opposite the printhead. In one particular such embodiment, one or more of the components are mounted within the printer and not connected to actuators. In another such embodiment, one or more of the components remain connected to and moveable by the actuators.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems, applications or methods. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. An imaging device comprising:

a printhead including an aperture plate defining a plurality of apertures, the printhead configured to emit liquid ink through the plurality of apertures of the aperture plate;

a plate positioned with reference to the aperture plate to enable a liquid ink layer to form between the plate and the aperture plate with ink emitted from the printhead;

a pressure source operatively coupled to the printhead;

a receptacle;

an actuator operatively connected to the plate; and

a controller operatively connected to the printhead, the actuator, and the pressure source, the controller being configured to operate the printhead to emit the liquid ink to the plate to form the liquid ink layer, to operate the pressure source to pressurize ink within the printhead and emit ink from the apertures in the aperture plate, and to operate the actuator and move the plate to cover the receptacle selectively.

2. The imaging device of claim **1**, the controller being further configured to:

operate the printhead to emit an amount of ink from the printhead to the plate and a distance between the plate and the aperture plate is selected to enable the liquid ink to form the liquid ink layer without leaking from between the aperture plate and the plate.

3. The imaging device of claim **2**, the controller being further configured to:

operate the printhead to emit an amount of ink ejected to the plate and the distance between the plate and the aperture plate is selected to enable surface tension of the liquid ink layer to form a meniscus about a perimeter of the liquid ink layer between the aperture plate and the plate.

4. The imaging device of claim **1**, the controller being further configured to operate the actuator and move the plate with reference to the aperture plate to enable formation of the ink layer between the plate and the aperture plate.

5. The imaging device of claim **1**, the controller being further configured to:

operate the printhead to eject the liquid ink from the printhead to form the liquid ink layer.

6. The imaging device of claim **1** further comprising:

a wiper blade;

another actuator operatively connected to the wiper blade; and

the controller is operatively connected to the other actuator, the controller being further configured to operate the

other actuator and move the wiper blade to wipe ink from a portion of the aperture plate before operating the actuator operatively connected to the plate to cover the receptacle.

7. The imaging device of claim **1**, the plate further comprising:

a seal positioned along a perimeter on the plate.

8. The imaging device of claim **1**, the plate further comprising:

an absorbent layer mounted to the plate.

9. A method of imaging device operation comprising:

positioning at least one of a printhead and a plate having a seal along a perimeter of the plate with reference to each other at a distance to enable an ink layer to be formed between an aperture plate of the printhead and the plate with liquid ink emitted by the printhead; and

operating with a controller the printhead to emit liquid ink through a plurality of apertures defined in the aperture plate of the printhead to the plate to form the ink layer between the plate and the aperture plate.

10. The method of imaging device operation of claim **9**, the positioning at least one of the printhead and the plate comprises:

positioning at least one of the printhead and the plate such that the distance between the aperture plate and the plate enables the liquid ink emitted by the printhead to the plate to form the ink layer without leaking from between the aperture plate and the plate.

11. The method of imaging device operation of claim **10**, the positioning at least one of the printhead and the plate comprises:

positioning at least one of the printhead and the plate such that the distance between the aperture plate and the plate enables the liquid ink emitted by the printhead to the plate to form the ink layer with a meniscus about a perimeter of the ink layer between the aperture plate and the plate.

12. The method of imaging device operation of claim **9**, the positioning at least one of the printhead and the plate comprises:

operating with the controller an actuator operatively connected to at least one of the printhead and the plate to move at least one of the printhead and the plate with respect to each other.

13. The method of imaging device operation of claim **9**, the operating the printhead with the controller to emit liquid ink comprises:

operating the printhead with the controller to eject liquid ink to form the ink layer.

14. The method of imaging device operation of claim **9**, further comprising:

operating with the controller a pressure source operatively connected to the printhead to pressurize ink within the printhead to emit ink from the plurality of apertures in the aperture plate.

15. The method of imaging device operation of claim **14**, further comprising:

operating with the controller an actuator operatively connected to the plate to move the plate to cover a receptacle selectively.

16. The method of imaging device operation of claim **15**, further comprising:

operating with the controller an actuator operatively connected to at least one of the printhead and a wiper blade to move at least one of the printhead and the wiper blade with reference to each other to enable the wiper blade to wipe ink from the aperture plate before operating the actuator operatively connected to the plate to move the plate to cover the receptacle selectively.

17. A method of imaging device operation comprising:

positioning at least one of a printhead and a plate having an absorbent layer mounted to the plate with reference to each other at a distance to enable an ink layer to be formed between an aperture plate of the printhead and the plate with liquid ink emitted by the printhead; and

operating with a controller the printhead to emit liquid ink through a plurality of apertures defined in the aperture plate of the printhead to the plate to form the ink layer between the plate and the aperture plate.

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